Diversifying the Engineering Workforce

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ABSTRACT

Engineering, education to workplace, is not just about technical knowledge. Rather, who becomes an engineer and why says much about the profession. Engineering has a "diversity" problem. Like all professions, it must narrow the gap between practitioners on the one hand, and their clientele on the other; it must become "culturally competent." Given the current composition of the engineering faculty and the profession's workforce more generally, it behooves engineering education to diversify while assisting current and future practitioners in becoming culturally competent. Programs that work to diversify engineering are reviewed, with research and evaluation-based findings applied to education and workforce practice.

Keywords: diversity, faculty, workforce

I. GLOBALIZATION AND THE WORKFORCE

September 11, 2001, changed the world—including engineering. We became more acutely aware of, and then chronically concerned about, identifying who is friend and who is foe. Suddenly, diversity by ethnicity, race, and gender took on geographic proportions: Who can study in a U.S. university? Is it better that graduates stay here or return home? Does national security outweigh the global interest in workforce development? Can a profession anchored by U.S. markets thrive on increasingly foreign-born talent?

Today, one's personal profile is as relevant as what one knows and can do. Indeed, these characteristics are inseparable, especially in a country built on pluralism and multiculturalism. The reality of ethnic diversity has only grown, while our policy responses strike many as antagonistic, divisive, bureaucratic, and unworkable. All organizations must consider the *composition* of their participants—students, employees, customers, leaders—and not just their *number*, i.e., the difference between demand and supply. At the root of this issue are two imperatives—one demographic, the other educational [1].

To meet the United States' need for world-class talent in science, technology, engineering, and mathematics (STEM), higher education must develop an emerging U.S. talent pool that looks very different from decades past. The domestic economic climate will not ease this human resource challenge. The federal deficit, coupled with U.S. peacekeeping obligations to the world, will constrain the discretionary budget. This, in turn, will increase fiscal pressures on the states, especially on public higher education. Calls for heightened accountability, efficiency, and productivity from these non-profit institutions will intensify the need for colleges and universities to examine how they serve their various missions and clients [2].

A. Beyond Supply and Demand

If higher education does not supply the number and quality of degree holders to meet these needs, employers have an array of options to access them internationally or move operations offshore. In an age of globalization, companies seek markets that capitalize both on a diversity of labor and consumers. Two letters published (Mar. 22, 2004) in response to a recent *Time* cover story, "Are Too Many Jobs Going Abroad?" illustrate the dilemma. One observes, "If we accept the concept that free trade is good for the world, then jobs will be moved to wherever they can be done most cheaply." Another says, "Americans will feel that technological careers are no longer available to them." Engineering may be more susceptible to such market adjustments than most professions [3]. And sometimes, the world market option simply does not exist. As the director of research and engineering at the Pentagon says, the need for U.S. citizens in Department of Defense work is an "inescapable fact…[and] an issue of national security" [4].

In engineering alone last year, 46 percent of master's degrees and 57 percent of the doctoral degrees were awarded to foreign nationals [5]. Women now comprise only 10 percent of the tenured/tenure-track faculty in U.S. engineering colleges, minorities just 5.3 percent [6].

Other kinds of diversity (which are harder to measure)—learning style, worldview, problem-solving orientation, among many others [7]—by race, ethnicity, and gender are the dimensions that matter in the United States. That is what federal and state laws, beginning with the Decennial Census, direct us to count. It is how we keep tabs on who we are, what we do, and where we do it.

The reality today is that companies seek the most competent talent at the least costly wage. So we must decide what constitutes a balance of trade in human resources. Policies can provide incentives that lure students and relax or rigidify guidelines on who can be hired into the workplace. The consequence is how we retain or expel the degreed talent in our midst. These become market signals; yet we cannot gauge with certainty their impact on individual perceptions and career choices or on institutional postures and behaviors.

Diversifying the engineering workforce is thus complicated business on which the larger economic and political context impinges in various ways. But much is within the control of the engineering profession—the educators, the accreditors, and the employers. After all, diversity is about difference, particularly cultural difference, and how it is valued. Diversity for its own sake may speak to morality and fairness, but that is a *condition*. Better that we think of diversity as an asset, an enabler that makes teams more creative, solutions more feasible, products more usable, and citizens more knowledgeable [8]. Diversity arguably makes any profession, but especially science and engineering [9], more competent.

B. Engineering as Discipline and Profession

Degree data represent the aggregate outcomes of successful academic performance. We infer the rest: choices, decisions, opportunities. From the 2003 Engineering Workforce Commission data on earned engineering degrees, we infer this theme: a gathering storm [5]. While the national baccalaureate total swelled by 9.3 percent to 75,031, the fractions of this total awarded to African Americans, Latinos, and American Indians all declined. This continues a trend. Degrees earned by these three historically underrepresented groups peaked—in percentage terms—in 1999–2000 and have drifted downward ever since. Degrees to women have followed a similar trajectory—growth throughout the 1990s, with a percentage peak in 2000 at 20.6 percent of the total. In 2003, women represented 20.1 percent of the baccalaureates in engineering.

We would say that engineering has a diversity problem. This article suggests that engineering—education to workplace—has a bigger problem: cultural competence. It is an issue facing all professions as they prepare their workforces to narrow the gap between practitioners on the one hand and their clientele on the other. Cultural competence is "the willingness and ability of a system to value the importance of culture in the delivery of services to all segments of the population…. In particular, it is the promotion of quality services to underserved, racial/ethnic groups through the valuing of differences and integration of cultural attitudes, beliefs, and practices…" [10]. There are numerous Web sites and books devoted to cultural competence. Most focus on the helping professions (especially health and education); the delivery of services; and processes that facilitate communication, understanding, and respect that advance expert-client interactions.

The relevance of cultural competence to engineering is equally acute. Given the relatively homogeneous composition of the engineering faculty and the profession's workforce more generally, it behooves engineering education to assist current and future practitioners in becoming culturally competent. This will not happen quickly, but it must happen. Otherwise, engineering can anticipate grueling consequences: declining interest in engineering careers, sagging membership in professional associations, citizen distrust of engineering expertise, and even more formidable challenges in competing successfully with other disciplines to recruit, enroll, and educate a diverse student pool to completion of the baccalaureate.

Today, a lack of diversity—a modicum of cultural differences that race, ethnicity, and gender represent in the engineering classroom—underpins the future engineering workforce. How, then, ought the engineering education community respond? How do enrollment, retention, degree, and faculty hiring trends reflect engineering's willingness to adapt, reach out, and recognize both changing student demographics and the national/global context? These are research questions, but they go far deeper to the core values of the profession. It is a matter not only of *what* is taught, but moreover *who* is taught, and before that, who is academically prepared, mentored, and socialized to engineering as a career. To tackle such imposing questions, we must first briefly examine empirically, and in the most disaggregated form that data sources allow, the contemporary history of U.S. engineering participation.

II. The Data

A. Participation by Demographic Category

The demographics are clear. Although about a third of the school-age population consists of U.S. underrepresented minority students, over three-fourths (77 percent) of the working population in science, technology, engineering, and mathematics (or STEM) occupations is predominately white, with a fair representation of Asians (about 12 percent), but only about 11 percent African American, Latino, and American Indian participants. While women comprise about half of the school-age population, they represent only about a fourth of the STEM workforce.

Over the past thirty years, women and underrepresented minorities (African Americans, Latinos, and American Indians) have made much progress in earning baccalaureate degrees in engineering (Figure 1).

Despite this overall progress in baccalaureate degree production, the proportion of women and minority freshmen in engineering has been declining since 1995. Although the absolute numbers have

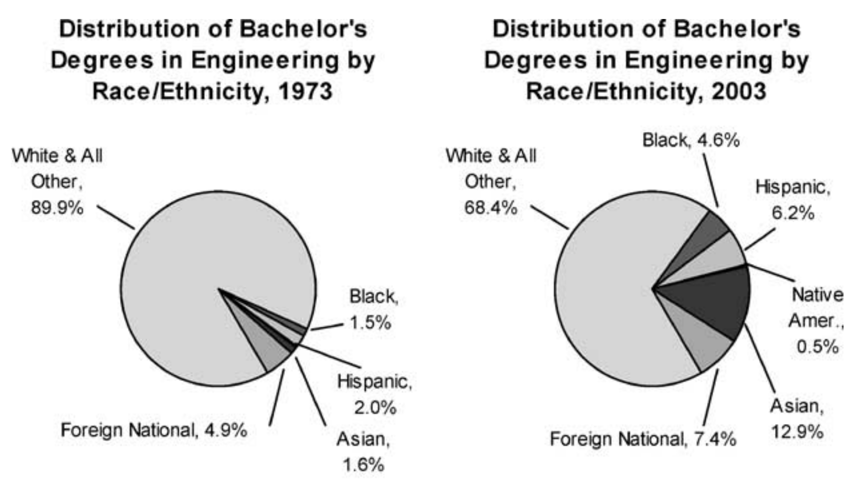

Figure 1. Who earns the B.S. in engineering? Source: CPST, data derived from the Engineering Workforce Commission.

been increasing for both women and underrepresented minority engineering freshmen, the numbers for men and nonminority freshmen have been increasing at a faster pace. In 1995, women represented 19.9 percent of the freshman class; in 2003, they represented 16.4 percent. In 1995, underrepresented minorities constituted 17.4 percent of the freshman engineering class; in 2003, they represented 16 percent [11]. These declines in the proportion of women and underrepresented minorities enrolled at the undergraduate level in engineering will likely translate into continued declines in the proportion of degrees earned by women and persons of color in the coming years.

Historically, about one-third of all bachelor's degrees have been awarded in science and engineering. Since 1970, the number of bachelor's degrees in science and engineering (S&E) awarded annually to men has fluctuated around 200,000, while the number of S&E bachelor's degrees earned by women has steadily increased, reaching parity in 2000 (Figure 2).

But women and underrepresented minorities are not represented equally across all fields. For example, in computer sciences, women's progress stalled and then reversed: in 1985, women earned nearly 37 percent of the baccalaureates awarded in computer science, but that number declined to 30.4 percent by 1990 and to 27.3 percent in 2001. Underrepresented minorities increased their proportion of baccalaureates in the computer sciences from 8.4 percent in 1981 to 17.4 percent by 2001. Non-U.S. citizens in computer science at the bachelor's level more than doubled from 3 percent in 1981 to 8.5 percent twenty years later (Figure 3).

With the exception of computer science for women, the declining representation of women and minorities at the baccalaureate level in engineering is *not* occurring in other STEM fields. This finding indicates both a retention and a recruitment problem: Women and underrepresented minorities are not entering undergraduate programs in engineering in the same proportions that they did several years ago.

The proportion of master's degrees earned by women and underrepresented minorities is also beginning to decline. Between 2002 and 2003, total master's degrees soared to 35,611. However, the percentage of degrees awarded to women, African Americans, and Latinos dropped, while the proportion earned by American Indians remained infinitesimal.

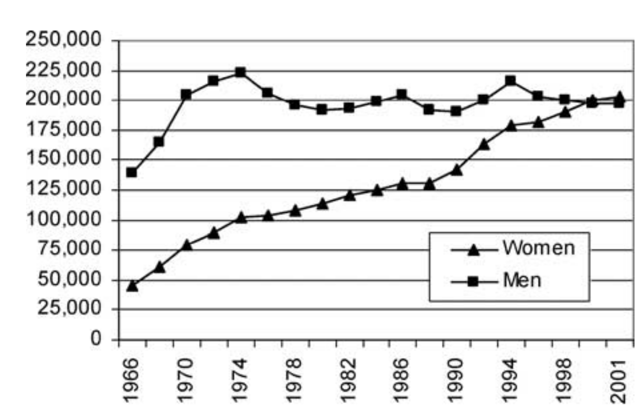

Figure 2. Bachelor's degrees awarded in science and engineering by sex, 1966–2001. Source: CPST, data derived from the National Science Foundation.

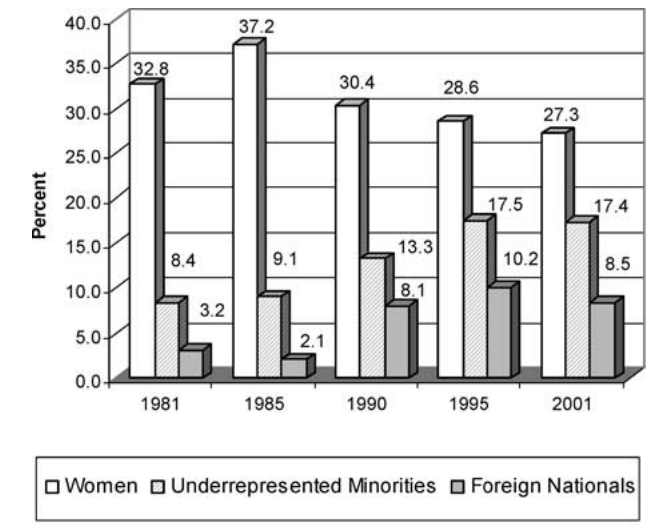

Figure 3. Proportion of bachelor's degrees in computer science awarded to women, underrepresented minorities and foreign nationals, 1981–2001. Source: CPST, data derived from the National Science Foundation.

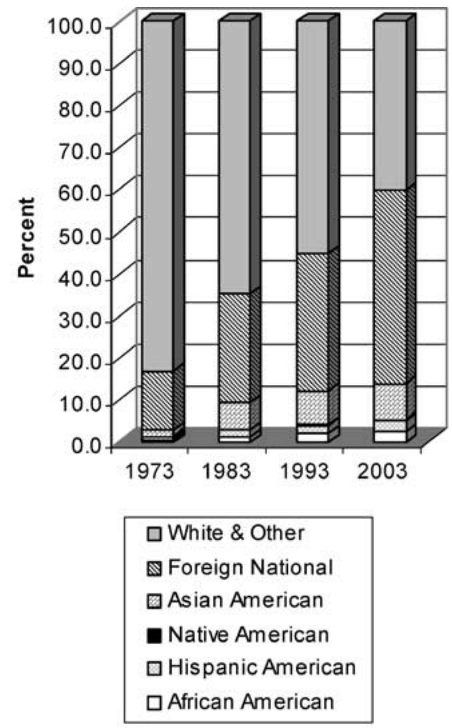

Figure 4. Distribution of master's degrees in engineering by race/ethnicity 1973–2003. Source: CPST, data drived from the Engineering Workforce Commission.

Despite the recent proportional drop, women and underrepresented minorities have made some progress in earning master's degrees in engineering. However, as shown in Figure 4, foreign nationals are now the largest group receiving these degrees.

The number of master's degrees awarded in science and engineering more than doubled in the thirty-five years from 1966 to 2001. In 1966, women earned 13 percent of the science and engineering master's degrees; by 2001, they earned 44 percent. The movement away from engineering does not extend to the sciences at the master's level. At the doctoral level, the numbers are so small that even when all underrepresented groups are aggregated, it is difficult to determine whether the pattern of movement away from engineering persists (see Figure 5).

The number of doctorates in science and engineering more than doubled from1966 to over 24,000 in 2002, accounting for 61 percent of all doctorates that year. But total S&E doctorates have declined in the last three years, and the number of doctorates awarded to U.S. citizens in S&E has dropped 12 percent since 1998, to 14,313. White males account for most of the decline.

U.S. citizens and permanent residents earned more than 15,000 doctorates in science and engineering in 2002, the eighth consecutive annual decline. Of this number, 9.5 percent were earned by African Americans, Latinos, and American Indians combined, 10.7 percent by Asians, and 76.8 percent by whites. Again, because of decreases among nonminorities, the proportion earned by the underrepresented minorities in science has been increasing slightly.

B. Institutional Performance

Some institutions of higher education have a tradition of success with all students, while some excel in the production of nonminority engineers. Far fewer are minority-supporting to degree completion. *Where* minority graduates earn their undergraduate degrees in STEM fields is more than a curiosity. They are a professional lifeline for many and, given the demographic future, they loom large in the production of the nation's technical workforce.

America's historically black colleges and universities (HBCUs) continue to play an important role in educating and producing African American science and engineering baccalaureates. The percentage of African Americans who earned their bachelor's degrees in science and engineering at HCBUs in 2001 was 26.5 percent, down from 29.1 percent in 1998, but slightly up from 2000. Latinos are most likely to attend colleges and universities in regions of the country where Latinos are most concentrated: California, Texas, and Puerto Rico (whose share has declined since 1990). American Indians also attend colleges and universities where their population is concentrated: California, Oklahoma, and Colorado. Almost all of the bachelor's degrees awarded to American Indians come from nontribal colleges (whereas tribal colleges are almost all two-year institutions).

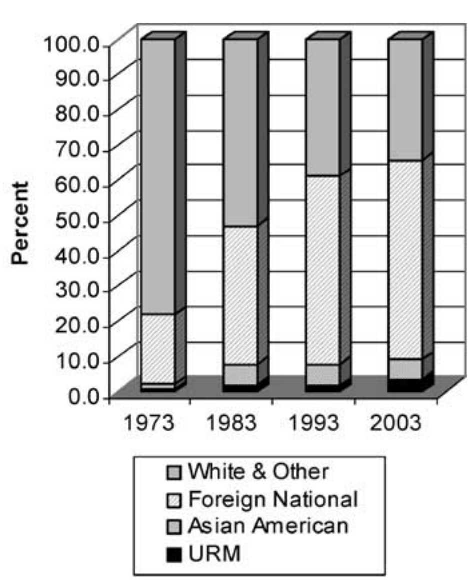

Figure 5. Distribution of doctorates in engineering by race/ethnicity, 1973–2003. Source: CPST, data derivied from the Engineering Workforce Commission.

It is not surprising that many of the top baccalaureate-origin institutions of African American science and engineering doctorate recipients are HBCUs, including Howard, Spelman, Hampton, Morehouse, North Carolina A&T, and Southern. For Latino S&E doctorate recipients, the top baccalaureate origins are again the institutions in Puerto Rico, but a number of Research I institutions play an important role, including Texas-Austin, UC-Berkeley, MIT, UCLA, and Texas A&M.

Variations among the top institutional producers of engineering baccalaureates by racial/ethnic group are striking. Some of this variation is geographic (proximity and access by certain populations), but some can also be traced to policies and practices that reflect institutional commitments to boost the production of engineers from underrepresented groups. These institutions should be lauded not only for their commitment, but moreover, for the observed results—a diversification of students earning the B.S. in engineering.

Utilizing data from an earlier NACME report by Chubin and Babco for 1998–2002, the average annual number of graduates was calculated for African Americans, Latinos, and American Indians [12] (Table 1). They found that institutions specialize: no one institution was among the top producers for *all* underrepresented groups in engineering. Some institutions, however, appeared on two lists—New Jersey Institute of Technology (African Americans and Latinos), North Carolina State at Raleigh (African Americans and American Indians), and Massachusetts Institute of Technology (Latinos and American Indians).

In all, the top fifteen producers for 1998–2002 distribute as follows. For African Americans engineering baccalaureates, an HBCU, North Carolina A&T, with an average annual number of baccalaureate graduates of 190, led the pack. Georgia Institute of Technology was second with 133 graduates. Not unexpectedly, the most prolific producers of Latino graduates were the University of Puerto Rico and the Polytechnic University of Puerto Rico, averaging 651 and 292 graduates, respectively. Among U.S. mainland institutions, Florida International followed by the University of Texas-El Paso excel. For American Indian baccalaureate graduates, Colorado-Boulder, with an average of fourteen graduates over the five-year period, set the pace, followed by Oklahoma State with thirteen graduates.

The NACME retention-to-degree analysis also found a slight improvement in the national minority retention rate to 38.8 percent, while nonminority retention slipped from 68.3 to 61.0 percent. Of the ninety-four institutions in the 2003 study with complete data, forty (42 percent) had underrepresented minority (URM) retention rates and thirty-eight (40 percent) had non-URM retention rates that exceeded the national averages. For the twenty-eight institutions with rates for both groups that exceeded the national averages, the differences in retention range from 1 to 34 percent. Two nonminority institutions in 2001 achieved higher

Top Producers of African American Engineers, 1998-2002

Institution	Ann. Avg. No. of Grads
North Carolina A&T	190.0
Georgia Institute of Technology	133.0
Florida A&M University	116.8
Prairie View A&M Univ	91.4
Tuskegee University	84.0
Morgan State University	75.4
Southern University	70.2
Howard University	67.8
North Carolina State Univ-Raleigh	63.8
University of Michigan-Ann Arbor	58.2
Tennessee State University	58.0
CCNY (City College, CUNY)	51.6
University of Maryland-College Park	43.4
Clemson University	43.2
New Jersey Institute of Technology	43.0

Top Producers of Hispanic Engineers, 1998-2002

Institution	Ann. Avg. No. of Grads
University of Puerto Rico	651.0
Poly Univ of Puerto Rico	292.2
Florida Intl University	129.6
University of Texas-El Paso	105.4
Texas A&M University	102.6
University of Texas-Austin	91.4
University of Florida	87.6
Texas A&M Univ-Kingsville	79.2
NM State University	64.0
Cal Poly-Pomona	63.0
Mass. Institute of Technology	60.2
University of New Mexico	49.6
University of Central Florida	49.2
New Jersey Institute of Technology	49.0
University of Arizona	46.0

Top Producers of American Indian Engineers, 1998-2002

Institution	Ann. Avg. No. of Grads
U Colorado-Boulder	14.2
Oklahoma State Univ	13.0
NM State University	9.0
Northern Arizona Univ	9.0
U Oklahoma	8.0
Mass Inst of Technology	7.2
U New Mexico	6.8
Arizona State University	6.0
NC State Univ-Raleigh	5.4
U Washington	5.4
U Alabama-Huntsville	5.2
U Tulsa	5.2
Michigan Tech University	5.0
U Arizona	5.0
Old Dominion University	4.8

Table 1. Top producing institutions of B.S. minority engineers. Source: Engineering Workforce Commission.

retention rates for URMs than for non-URMs—Tulane and West Virginia. Other institutions in which the retention rates were similar for URMs and for non-URMs were Colorado-Boulder, Villanova, Boston University, Carnegie Mellon, Pittsburgh, Delaware, Lehigh, Penn State, and Stanford.

The upshot of these data is powerful: all kinds of institutions of higher education can be "minority-serving." Indeed, as new research demonstrates, improving graduation rates may be the chief mechanism for diversifying U.S. engineering (and the professions more generally) [13]. As Figure 6 shows, workforce participation by women and underrepresented minorities over the last twenty years has grown modestly—from 6 percent to about 11 percent for women, 2.7 percent to 4.5 percent for African Americans, and 2.2 percent to 4 percent for Latinos employed in engineering.

C. Beyond Research Findings

Clearly, much remains to be done to assure opportunities for all to pursue STEM-based careers and to make the talent pool from which future engineers are drawn more inclusive. Given the trends in participation and performance recounted here, the prospects for changes in practice that over time would diversify the engineering workforce have yet to reach the core of engineering [14–15]. This is despite a mountain of research and the good intentions and labor of sponsors and educators alike.

As U.S. institutions have become increasingly performance based, the "best practices" movement that originated in the corporate sector has led to a corresponding search for excellence in performance in organizations and programs of other types. This search extends from workforce-focused Malcolm Baldrige

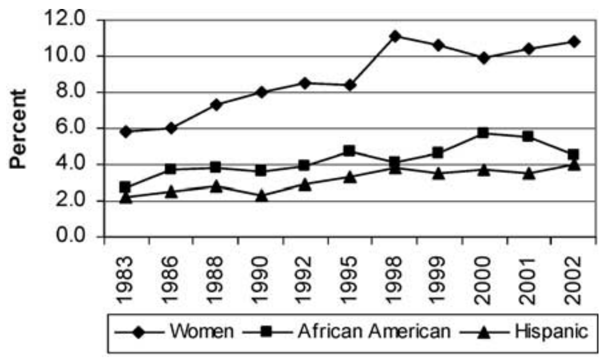

Figure 6. Women and minorities as a percent of the U.S. engineering workforce, selected years, 1983 to 2000. Source: CPST, data derived from the Bureau of Labor Statistics.

National Quality Awards to the learning expectations for pre-college students contained in the No Child Left Behind Act. Higher education—and diversity programs in particular—are not exempt from this movement toward performance and accountability.

To meet demands for program accountability, more evaluation of interventions, i.e., what makes a difference, is being conducted. Looking across such program evaluations and reviews allows analysts to synthesize and distill the ingredients of successful programs. We are learning not only what works, but *why* and *how*, as illustrated by a two-plus-year effort conducted by the public-private partnership, Building Engineering and Science Talent (BEST).

In three reports, BEST reveals much about the dimensions of the diversity challenge [1]. In one report, BEST reviewed 124 higher education intervention programs aimed toward increasing the participation of underserved groups in science and engineering. The purpose was to define what higher education practices work to keep women and minorities on the path to careers in STEM professions. A set of design principles was formulated from the program review and proposed to higher education and employers in all sectors willing to reaffirm and institutionalize their commitments to diversity.

The 124 U.S. higher education-based programs were rated by BEST on criteria covering goals, impact, growth, sustainability, and evidence of effectiveness. The programs were then reduced to thirty-six finalists by a Blue Ribbon Panel in 2003. Twelve emerged as "exemplary" and "promising" programs. Eight components of those programs constitute design principles for expanding the capacity of higher education institutions to support their student clientele in achieving educational milestones that mark the transition from school (and degree) to work (and career). Those principles are summarized in Table 2.

With such principles in hand, faculty and other university personnel have a tool to guide behavior. *How* to implement each principle in the particular campus and department environment is, of course, a formidable challenge. One size hardly fits all. BEST cautions further that these principles comprise a package (not an a la carte menu), may require work after mistakes are made and corrected, demand execution not only of particular activities but of sufficient amount and quality, and must be adapted to evolving conditions—emerging knowledge, new technologies, eroding boundaries between work and home, and demographics that continue to change the context and culture of teaching and learning.

Finally, BEST argues that both expanding the application of best practices and deepening their use on campus are not enough. Institutions must embrace them as a means to advance their educational mission. In other words, practices must be sustained over

Principle	Evidence
Institutional leadership	Commitment to inclusiveness across the campus community
Target recruitment	Investing in and executing a feeder system, K-20
Engaged faculty	Developing student talent as a rew arded faculty outcome
Personal attention	Addressing, through mentoring and tutoring, the learning needs of each student
Peer support	Student interaction opportunities that build support across cohorts and allegiance to institution, discipline, and profession
Enriched research experience	Beyond-the-classroom hands-on opportunities and summer internships that connect to the w orld of w ork
Bridging to the next level	Institutional relationships that help students and faculty to envision pathw ays to milestones and career development
Continuous evaluation	Ongoing monitoring of process and outcomes that guide program adjustments to heighten impact

Table 2. Design principles to expand higher education capacity. Source: BEST, A Bridge for All, **February 2004, p. 5.**

time and institutionalized to become indistinguishable from "standard operating procedures." This is the critical point where programs cease to exist as special funded efforts (from the outside) and serve as the department desideratum (supported by the institution's operating budget). Once such status has been attained, the hope for scaling *across* departments and institutions becomes more realistic. An increase in scope improves the likelihood that wherever students enroll in engineering, they will have a fair chance to earn a degree in an environment that simultaneously prepares them for the world of work and creates the conditions for success.

If further progress is to be made in building the capacity of colleges and universities to diversify the STEM workforce, many more programs must meet the BEST standards. And measuring progress is a challenge. Higher education institutions, sponsors, and employers alike must develop appropriate indicators of diversity performance so that the impact of initiatives can be gauged. A "diversity scorecard," for example, was developed by fourteen California higher education institutions, as racial/ethnic minority groups were fast becoming the majority in the state and students of color were falling further behind in their preparation for postsecondary education. Historically in California, the diversity agenda had been primarily about access to predominantly white institutions. Yet, as in many other states, urban colleges—private and public, two- and four-year—increasingly serve as the main entry point into higher education for minority students [16].

The core principle of the diversity scorecard is that data on the state of equity in educational outcomes for African Americans and Latinos can increase recognition by faculty members, administrators, counselors, and others about the existence of inequities. To bring about institutional change, individuals have to see, as clearly as possible, the magnitude of inequities, rather than having researchers tell them that inequities exist. The project has four goals for California: close achievement gaps among racial/ethnic groups, raise the education level of the workforce overall, reverse the growing economic polarization among racial lines, and provide an example to the nation as a whole.

Two other works with roots in the corporate world—Hubbard's *Measuring Diversity Results* and *How to Calculate Diversity Return on Investment* [17–18]—can assist institutions in developing a diversity scorecard. Such a scorecard provides a step-by-step approach to measuring the benefits of diversity and converting them into actual dollars. The approach offers a comprehensive, strategic process to measure, analyze, track, and report one's diversity initiatives to demonstrate their value. It makes the "business case" for diversity.

Hubbard has also developed automated software technologies for measuring diversity return-on-investment and performance improvements. His reports help organizations understand what counts when measuring diversity and how to connect diversity back to the bottom line, i.e., how to get the best return for the organization on its investment in diversity staff and initiatives. He assists organizations with staff development, quality improvement, performance improvement strategies, and restructuring work teams to utilize the strengths of a multi-ethnic workforce. Such strategies should apply to colleges of engineering and their faculty, though the academic reward system (promotion, merit raises, tenure) has always favored, in the tradition of academic freedom, individual rather than team achievement. If corporations can make the business case for diversity, U.S. universities should make the academic case.

III. THE DYNAMICS OF CHANGE

A. Programs that Support All Students along the Engineering Pathway

As we have shown, a disturbingly narrow range of citizens is pursuing STEM careers. The current and projected need for more STEM workers, coupled with the chronically lagging participation of students from ethnically growing segments of the population, argue for policies and programs that increase the pathways into engineering. Developing such policies requires that the barriers obstructing entry and progress in STEM fields be addressed proactively. Interventions that flow from research and influence policy are indispensable in the current climate.

To prepare a diverse and culturally competent engineering workforce, the educational environment for engineering students must be systematically improved across all levels of the K-16 educational continuum and beyond. Particular attention must be paid to transition points along that continuum (i.e., high school to college, college to graduate school, graduate school to workforce) because women and minorities leave the engineering path at each of these transitions in greater proportions than nonminorities and men [19]. Systemic improvement requires policy solutions and programmatic strategies that affect practice. The remainder of this section focuses on a selection of successful and increasingly visible examples, including some not captured by BEST. In particular, we highlight best practices in student preparation, recruitment, admissions, financial assistance, and academic enrichment, building the research agenda as we go.

1) Pre-college preparation: Targeted strategies have been shown to have the potential to increase the number of underrepresented pre-college (K-12) students progressing to college STEM programs. An effective pre-college program must (1) promote awareness of the engineering profession, (2) provide academic enrichment, (3) have trained and competent instructors, and (4) be supported by the educational system of the student participants (i.e., the school and/or school district).

The objective of the Detroit Area Pre-College Engineering Program (DAPCEP) is to increase the number of historically underrepresented minority students (African American, Latino, American Indian) who are motivated and prepared academically to pursue careers in engineering, science, and mathematics related fields. DAPCEP partners with high schools, universities, and businesses to provide educational programs for elementary, middle, and high school students.

Founded in 1976 with a grant from the Alfred P. Sloan Foundation, DAPCEP is recognized nationally as a model for pre-college engineering programs and teacher training [20]. Through DAPCEP, more than 6,000 students at more than sixty middle and high schools are provided a suite of opportunities (including scholarships) to help them develop academic and professional qualities to make them valuable members of the STEM work force. DAPCEP is governed by an eighteen-member board of directors representing the Detroit public schools, local universities, and corporations. In addition, DAPCEP incorporates an advisory committee of approximately fifty parents that meets monthly to support program goals.

DAPCEP programmatic offerings consist of a summer academic skills development program, Saturday enrichment classes, and in-school pre-engineering classes. Key aspects of DAPCEP's in-service training program include its year-long continuity, as well as its integration into the Detroit Public School System. With the focus of DAPCEP classes on enrichment rather than remediation, more than 25,000 students have cultivated their STEM training and awareness in DAPCEP programs since its inception. About 90 percent of these students have gone to college, and more than 70 percent have pursued degrees in STEM fields.

2) The undergraduate transition: A notable undergraduate transitional strategy is the dual-degree program, which builds on the success of minority-serving institutions in attracting minority students. In this model, participating students receive a bachelor's degree in liberal arts from one school and a bachelor's degree in engineering from a second institution. By joining forces, the partner institutions afford a large pool of undergraduate (and typically minority) students the opportunities and exposure that link recruitment and retention. The strength of such programs lies in combining the unique strengths of the participating institutions.

A good example is the dual-degree engineering (DDE) program established by the Georgia Institute of Technology, Morehouse College, Spelman College, Clark Atlanta University, and Morris Brown College. The latter four historically black colleges and universities have offered a dual-degree program to undergraduates seeking engineering degrees since 1969. Upon completion of the program, students receive a bachelor's degree from the first school and a bachelor's degree in one of the engineering disciplines at Georgia Tech. Typically, more than 100 African American students are completing B.S. degrees at Georgia Tech through this program in any given year.

The objective of the DDE program is to provide a framework for the pursuit of a baccalaureate degree in an engineering discipline with the added benefits of a liberal arts education. Today, the program has expanded to include the four undergraduate institutions in the Atlanta University Center (Clark-Atlanta, Morehouse, Morris Brown, and Spelman) and other engineering institutions such as Auburn, Boston University, Dartmouth, North Carolina A&T State, Rensselaer Polytechnic Institute, and Rochester Institute of Technology. Since 1974 (the year of the first DDE graduate) more than 800 minority students have graduated from the program [21].

Intervention programs to remove educational barriers for minority engineering students should increase students' time and energy devoted to studying, time spent on campus, interaction with other students, interaction with faculty, and participation in student organizations [22]. The grandfather of such interventions is the California Minority Engineering Program (MEP) (though today such programs have "diversity" or "enrollment services" in their names). MEP was initiated through a faculty-led effort at California State University, Northridge in 1973 [23–24]. The MEP model has been successfully replicated at more than 100 universities and privately sponsored programs incorporating the following key structural elements: a formal orientation course for new freshmen, clustering of underrepresented students in common sections of their classes, a student study center, and structured study groups.

More recently, other structural elements, such as student and faculty surveys and other assessment tools, rigorous peer and professional advising efforts, undergraduate research programs, and even computer-aided learning, have been added to the MEP paradigm. The California Postsecondary Education Commission evaluated twelve MEPs in 1985 and found that students participating in these programs were being retained at higher rates than all engineering students at each of the twelve institutions, and at three times the rate of minority students not participating in the programs. Equally impressive were statistics from the program at UC-Berkeley, where participating students earned on average one letter grade higher in their math and science courses than nonparticipating minority students, and exceeded the average grades achieved by white students in the same courses [25]. For a national perspective on MEPs and the "diversity" offices to which many have evolved, see [26].

The Meyerhoff Scholars Program, which began as a collaboration between philanthropists Robert and Jane Meyerhoff and the University of Maryland, Baltimore County (UMBC) in 1988, takes the MEP model to a new level. Designed to increase the number of underrepresented students eligible to pursue graduate degrees in science and engineering, this program focused on African American students. In 1996, it was opened to all since UMBC is a public institution. Between forty and sixty Meyerhoff scholars are accepted into the program each year from more than 1,400 applicants.

Meyerhoff students have achieved higher grade point averages, graduated in STEM at higher rates, and gained admission to graduate schools at higher rates than several comparison groups, including (1) a pre-Meyerhoff sample of African American males with comparable entrance qualifications, (2) STEM students who were offered Meyerhoff scholarships, but chose to enroll at other institutions, and (3) historical cohorts of academically comparable minority and nonminority STEM students at UMBC. Student survey and interview data have revealed that several program components have been critically important to student success. These components include community aspects of the program, the use of study groups, a summer bridge program, adequate financial support (contingent upon the maintenance of a B academic average), supportive program staff, mentoring, and the availability of internships (particularly summer research internships). These components, in combination, are remarkably similar to those found to relate to success in the MEP model [27]. In 1996, the Meyerhoff program received a Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring. BEST cited it as an exemplary program in 2004.

3) Graduate recruitment and transition: A key factor for motivating students to pursue advanced degrees and research careers in science and engineering is a fruitful research experience as an undergraduate. According to a recent study by SRI International [28], undergraduate research programs can help students who are uncertain about going to graduate school to clarify their intent; such programs can also bolster the certainty of students who have already decided to pursue graduate education. While some students are unsure about pursuing graduate education at all, others want an advanced degree but are uncertain about the other variables involved in this decision (i.e., what school to attend, M.S. versus M.B.A., etc.). Ultimately, the decision of minority students to attend graduate school is profoundly affected by the amount of faculty involvement in their undergraduate career [29]. Quality interactions with engineering faculty can have a significant impact on a student's decision to pursue graduate education.

The availability of financial aid, at both the undergraduate and graduate levels, impacts students' decisions to enroll in postsecondary education, choose a specific major, and complete a degree [29]. Financial aid is especially critical for minority students, who resist assuming a burden of debt. Meeting the financial need of minority engineering students has been shown to be crucial for reducing attrition [30].

The National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc. (GEM), a nonprofit organization formed in 1976 to address the issue of financial need at the graduate level, provides financial support in the form of graduate fellowships to American Indian, African American, and Latino students pursuing graduate degrees in STEM disciplines. GEM Fellows also obtain practical work experience through summer internships at GEM employer worksites.

GEM is jointly sponsored by a consortium of university and company members engaged in activities that span beyond recruitment and retention, leading to graduation from master's and doctoral programs in engineering and science. This is accomplished by identifying and attracting talented students to graduate school in STEM fields and providing the most cost-effective process for matching students with the needs of member universities and company sponsors. GEM offers M.S. and Ph.D. engineering, as well as Ph.D. science fellowships. It also provides courses to prepare undergraduates to succeed in graduate curricula. Since its inception, GEM has supported nearly 2,400 master's and 150 doctoral degrees, in STEM disciplines, awarded to underrepresented students [31]. GEM, too, was recognized by BEST.

4) Graduate education and beyond: To recruit a diverse and culturally competent cadre of faculty, the desire for an academic career must first be cultivated among graduate students. This objective is addressed in part by the National Science Foundation (NSF) Alliances for Graduate Education and the Professoriate (AGEP) program, which seeks to increase significantly the number of underrepresented students receiving doctoral degrees in STEM disciplines. The scarcity of role models and mentors constitutes a significant barrier to producing minority graduates, so the NSF is particularly interested in increasing the number who enter the professoriate in these disciplines.

Initiated in 1998, the specific objectives of the AGEP program are to (1) create and implement innovative models for recruiting, mentoring, and retaining minority students in doctoral programs and (2) develop effective strategies for identifying and supporting underrepresented minorities who want to pursue academic careers. AGEP also supports a research effort to identify major factors that promote the successful transition of minority students from (1) undergraduate through graduate study, (2) course-taking in the early years of the graduate experience to independent research required for completion of a dissertation, and (3) the academic environment to the workplace. Thirty AGEP alliances, involving more than 100 universities and colleges, currently exist nationally [32].

The Compact for Faculty Diversity, a partnership of three regional higher education associations—the Western Interstate Commission for Higher Education, the Southern Regional Education Board, and the New England Board of Higher Education—was created to address the paucity of minority faculty in U.S. colleges and universities. The Compact draws on the resources of state higher education offices, colleges and universities, graduate departments, faculty, and students. Its dual objectives are to increase the representation of STEM faculty of color in our nation's universities and to provide a framework for systemic change in graduate education.

As reviewed above, faculty representation by groups underrepresented in STEM has remained virtually unchanged in the past twenty years, with most of those employed at minority-serving institutions. In contrast to student attrition rates approaching 50 percent in doctoral programs nationally, the Compact has retained 90 percent of the 650 minority doctoral scholars who have entered the program since its inception in 1994 [33]. Each of the partners in the program has a specific role in ensuring student success. States, universities, federal agencies, and foundations provide financial support. Academic departments create environments of social and academic support. Finally, faculty offer mentoring and advising. The three regional partners in the Compact sponsor an annual Institute on Teaching and Mentoring that assembles students and faculty to participate in seminars on preparing for faculty careers and effective mentoring. The Compact is another program, one of the few faculty-focused, hailed as effective by BEST.

B. Diversifying the Faculty: What It Will Take

The foregoing provides glimpses of programs that work in identifying, attracting, enrolling, supporting, and graduating engineering students. We can learn from them all. Engineering, in addition to increasing its capacity to support the academic success of its students, must replace an aging faculty with a more culturally competent generation. Such change would be the most welcoming advertisement for engineering careers.

According to the Commission on Professionals in Science and Technology (CPST), underrepresented minority representation drops significantly from B.S. degree to advanced engineering degrees though this represents a slight increase over the previous decade. Only 5.3 percent of master's and 3.5 percent of doctoral degrees awarded in 2003 were earned by these minority students [34]. This has predictably led to a paltry number of tenured, underrepresented minority STEM faculty (8 percent) [35].

The need for a more diverse population of STEM faculty is compelling. NSF data show that women Ph.D. scientists and engineers employed in educational institutions were less likely than men to hold the rank of full professor or to be tenured, even after adjusting for chronological age (36 years) or years since the doctorate. Doctoral faculty who are minority are barely visible, regardless of field—less represented at the highest ranks and less likely to be tenured. African Americans and Latinos comprise about 3 percent of the engineering faculty, with even less representation at the full and associate professor levels.

Data on tenured/tenure-track faculty compiled by the American Society for Engineering Education [6] show some evidence of growth for women, to 10 percent in 2003. While no gain was observed for African Americans, and only a minimal increase was observed in Latino representation (to 3.2 percent), there was a marked increased in Asian faculty members to 19.2 percent (see Figure 7).

Large variations exist by discipline in tenure/tenure-track proportions of African Americans, Latinos, and women in engineering.

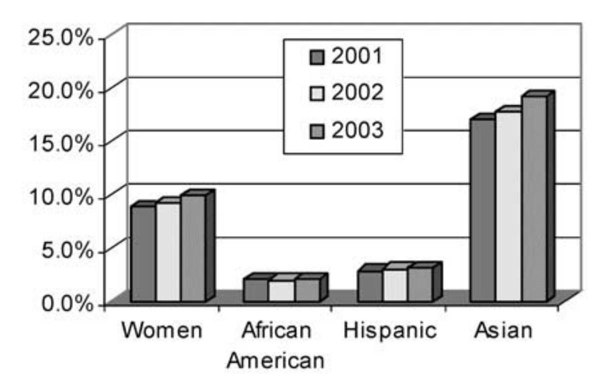

Figure 7. Percentage of women and minority faculty members, 2001–2003. Source: CPST, data derived from ASEE Profiles of Engineering and Engineering Technology Colleges, 2003 Edition.

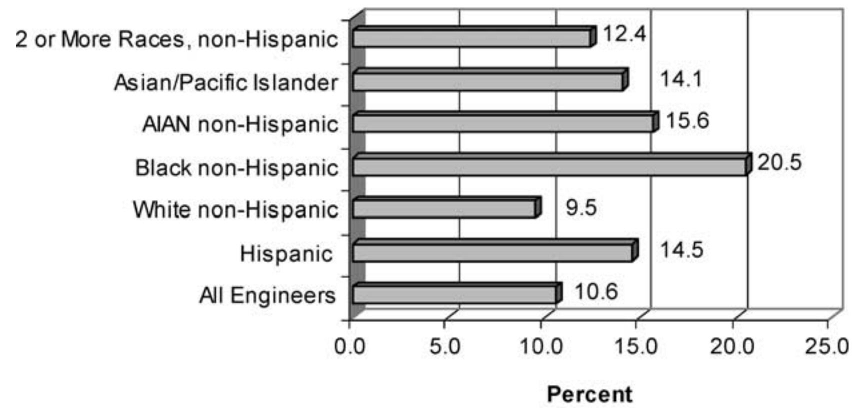

Figure 8. Proportion of engineering workforce who are women by race/ethnicity, 2000. Source: CPST, data derived from the U.S. Bureau of the Census.

The highest proportion of African Americans who were tenured or in tenure-track positions was in architectural engineering. The lowest proportion was in computer engineering, where only one percent of African Americans were in tenure-tenure-track positions. For Latinos, almost the reverse was true. The highest proportion of Hispanics who were tenured or in tenure-track positions was found in computer engineering (7.1 percent), while the lowest was in architectural engineering.

These low percentages for African Americans and Latinos contrast with the 26 percent of Asians tenured or in tenure track positions in electrical engineering and the 16.6 percent of women in biomedical engineering. Put another way, among almost 10,800 full professors—half the engineering teaching faculty—only 424 were underrepresented minorities in 2003 compared to 1,914 Asians and 7,785 whites. This might be called the legacy of a stunted pipeline.

Examining the engineering workforce by race/ethnicity and gender reveals an unexpected finding: women, and African American women in particular, are much more represented than are whites, as shown in Figure 8.

The education of a diverse community of scholars must be a persistent theme: improving the numbers of women and underrepresented minority faculty, increasing the number of such faculty who are tenured, and promoting the numbers of women and minorities in upper-level administrative positions. After all, tenured professors and department heads control resources, change values, promote excellence, and reward performance. Moreover, they wield influence by modeling faculty behavior. There is now research recognition of this, but solutions to make more of it happen—for the good of both the candidate faculty and the institution—remain elusive.

Efforts to change, as well as understand, the composition of the S&E faculty—that sector of the academic world with great potential to reach large numbers of students—are daunting. Among the challenges faced by the twenty-first century university is how to grow and nurture a culturally competent faculty—irrespective of race, ethnicity, gender, age, and other variables. Ultimately, the faculty must become adept at encouraging the success of all students.

We cannot diversify the undergraduate and graduate student bodies in STEM, however, without diversifying the environments in which they live and become professionally socialized. So, the burden rests squarely on the faculty and the administration to attract and retain faculty who share this conviction and model best practices [37]. Several activities and programs that facilitate the recruitment, retention, and promotion of faculty members from underrepresented groups are discussed below.

1) Best practices for achieving faculty diversity: In addition to programmatic efforts, university administrators should also consider forming campus working groups that are charged with facilitating minority faculty recruitment and retention issues at peer institutions. These working groups would consist primarily of faculty members who undertake activities such as conducting on-site visits at peer institutions with the goal of acquiring information and discussing strategies for increasing the minority faculty on their campuses. These visits afford the opportunity to meet with minority graduate students and to flesh out a structure where peer institutions can recruit neophyte Ph.D.s outside their institution to academic appointments.

Other potential approaches include the following:

- Formalizing underrepresented faculty and postdoctoral recruiting exchange activities with small groups of peer schools.
- Establishing endowed professorships for outstanding underrepresented junior and mid-career faculty.
- Encouraging departments to carefully consider the hiring of outstanding doctoral graduates of their own programs.
- Providing incentives (such as subsidized or partially subsidized faculty lines) for schools able to recruit outstanding underrepresented minority faculty.
- Including the recruitment of underrepresented faculty in the annual evaluation process for department chairs [38].

In engineering, U.S. universities currently award fewer than 150 doctoral degrees to minorities each year. Given such small numbers, there is no reason that *every one* of these individuals cannot be tracked and recruited to potentially pursue an academic career. Needed, of course, are the resources and will to propagate such efforts.

2) Finding and creating culturally competent faculty : As minority scholars complete their degrees and enter the professoriate, their presence will magnify the diverse intellectual talents they bring with them and the unique contributions they make as members of groups long missing from the ranks of engineering and science faculty. Such diversity can only enhance the quality of our nation's postsecondary enterprise, while changing the face of the role models for succeeding generations of scholars and citizens.

The literature on how to search for, attract, and hire university faculty has grown in recent years as part of the analysis of doctoral education and the preparation of future faculty [39–40]. The lack of faculty diversity by race, ethnicity, and gender is a *university* problem (as the data reviewed above illustrate), not one of engineering alone. What will separate the disciplines is a willingness to structure searches to compete for the available talent while developing more minority and women talent in the pool of new doctorates. This cannot happen overnight, but it *can* happen.

To demonstrate the dimensionality of the challenge, consider the findings of a study of University of California (UC) system (nine campuses) faculty hires for the years 1980–90. A total of 13,700 Ph.D.s were awarded in science and engineering during that period, with 206 (0.15 percent) earned by persons of color. MacLachlan [41] interviewed the 160 who held an academic position in the succeeding decade. Only seven of the 160 were engineers of color and two were women. Besides the chronic underrepresentation, MacLachlan learned through the interviews that despite the lack of access to faculty positions in institutions similar to those found on UC campuses, minority and women faculty want to "give back," foster diversity among the students with whom they work, and seek the same satisfactions and creature comforts (affordable housing, quality schools) that other faculty crave. That they pursued an academic career attests to their persistence; they are anomalies.

3) Structuring faculty recruitment: An antidote to the UC experience comes from Daryl Smith [42], who consults for institutions wishing to conduct searches for culturally competent faculty. She calls the search process "interrupting the usual," departing from standard practices that consider research productivity the only coin of the academic realm. The university must disseminate its search for minority scholars in publications other than *The Chronicle of Higher Education* and *Science*, such as *Black Issues in Higher Education*. The key is committing the resources to assemble a qualified pool that includes candidates of color and both sexes. The issue is one of opportunity to compete, or in Smith's word's, of "getting in, then getting on" with one's career.

How common is a college of engineering faculty of 300 or more that offers no more than two handfuls of minority or women professors? What is the likelihood that a college of engineering that advertised 112 faculty positions in a 2003 ASEE *Prism* will hire in the next four years more than a handful equipped to nurture a diverse engineering student body? Clearly, interventions at many levels are needed. In the short run, the composition of U.S. engineering faculty will not change much. In the long run, such change is essential if the faculty and the profession are to grow a cadre of practitioners and consumers that reflects the multiculturalism of the U.S. population. In academic engineering in particular, whether one examines the ranks of those on the tenure track, at the full professor level, department chairs, or deans, women and minorities are scarce commodities [43–45].

This scarcity has both substantive and symbolic repercussions, as studies of mentorship [46–47] continue to demonstrate. In the world of role models, who occupies which positions can influence and inspire—even at a distance. Thus, better integrating campus chapter organizations, such as the Society of Women Engineers, the National Society of Black Engineers, the Society of Hispanic Professional Engineers, and the American Indian Science and Engineering Society, into the operations of engineering—universities, professional societies, and companies—would seem a prudent and eminently feasible intervention strategy. A remote delivery network targeting women already exists: MentorNet is the award-winning nonprofit e-mentoring network that addresses the retention and success of women in engineering, science, and mathematics. To further women's progress in scientific and technical fields through the use of a dynamic, technology-supported mentoring program, MentorNet since 1998 has made more than 11,000 matches. It also conducts extensive evaluation of its programs, including an analysis that documents the positive impact of mentoring, especially on an understudied population—women of color [48–49].

Through MentorNet in particular, engineering societies could identify mentors within their memberships. Mentors could be paired with student protégés identified from university-based student chapters as well as students majoring in disciplines that are relevant to a particular society. Without a huge expenditure of funds, such an effort would support, even at a distance, the overall goal of retaining to the baccalaureate women and students of color in engineering.

IV. The Continuing Challenge

Economist Lester Thurow said (in *Head to Head*: *The Coming Economic Battle among Japan, Europe and America*) that "in the twenty-first century, the education and skills of the workforce will end up being the dominant competitive weapon." In the early stages of the current millennium, it is important to acknowledge that the U.S. economy has enjoyed unprecedented global leadership, in large part because of a technological revolution that has spawned greater productivity and a host of new industries and jobs. In this climate, it is possible to lose sight of the precarious nature of this prosperity. The U.S. economy remains critically dependent on—and thus vulnerable to any deficiencies in—the talents and knowledge of the available technical workforce.

Recent policy reports [50-51] have eloquently identified the perils inherent in a society characterized by ethnic, gender, and socioeconomic disparities. While progress has been made over the past twenty years, the risk remains. The business community is not alone in its need to develop and maintain a highly skilled, domestic, and culturally competent STEM workforce. Both academe and the federal government also have a vested interest in finding ways to deepen the pool of science and technology educators, researchers, and administrators.

Nevertheless, STEM workers are overwhelmingly white, male, and disability-free, while the available pool of talented women, minorities, and persons with disabilities remains significantly underutilized. In contrast, these groups together constitute a little more than two-thirds of today's U.S. workforce. The current and projected need for STEM skills compels policies, programs, and *resources* that support greater participation by these groups in STEM education and careers.

A. Leadership: Academic and Corporate

Studies have shown that appropriate investment in preparing a diverse workforce can yield substantial economic benefits to the nation [52]. A survey conducted by the American Management Association of more than 1,000 of its members found that heterogeneity—a mixture of genders, ethnic backgrounds, and ages—in senior management teams consistently correlated with superior corporate performance in areas such as annual sales, growth revenues, market share, shareholder value, net operating profit, worker productivity, and total assets [53]. In academia, a key strategy for generating and maintaining a diverse STEM student body is establishing similar diversity among the STEM faculty who serve as role models for that student body. In short, a culturally competent workforce creates a competitive advantage.

Ultimately, those taking pathways to engineering will lead the profession, either through the faculty ranks or scaling the corporate ladder. How such mobility draws on those who historically have largely been missing from the corps of leaders will influence generations of students who will either see career opportunity or arrested development. The choice is not just theirs, but that of the current community—leadership and rank and file alike. If engineering is to be a beacon to U.S. society, the choice is clear.

B. A Research Agenda

Research can inform not only what we *do*, but more importantly, *how we know* what to do. From the foregoing emerges a research agenda with an eye toward action, namely, knowledge that is actionable in the sense of suggesting what to do, if not how. To put it unequivocally, we advocate a practice-based research agenda focused on participation issues in engineering, namely, the declining interest in engineering careers, sagging membership in professional associations, distrust of engineering expertise, and lags in competing with other disciplines to recruit, enroll, and educate a diverse student talent pool. In brief, we envision the following research priorities:

1) Image and outreach: If engineering is to compete for student talent, it must be seen as inviting youth to prepare for a demanding, productive, and lucrative career. The NAE and ASEE recognize that the image of engineers and engineering as a career choice is an issue requiring outreach to middle and high school students and to those who influence them. What has been the impact of advertising such opportunities? How do images of who is an engineer, where they work, and what they do affect student choices? How, in particular, does a campaign such as National Engineers Week measure its effectiveness in informing, spurring interest, and connecting curious students—compared to other influences—with role models, organizations, and media that can help to cultivate aspirations?

2) Climate for success: What would be different in the engineering classroom and overall experience of the undergraduate if the faculty were more culturally competent? We need to establish a baseline of cultural sensitivity and then test the assertion that faculty are willing to become culturally competent. Subsequent research on how an education that values gender, ethnicity, and geography yields more supportive, collaborative, and creative engineers would be both revealing and instructive. What skills—as mentors and coaches—do engineering faculty, tenured and neophyte alike, need to acquire and practice? How would we measure "success" in teaching and learning? Redistribution across engineering majors? Lower attrition and higher GPAs? Different entry-level job choices?

3) Retention or graduating more engineers: Nationally, fewer than two in five minority first-year students who enter engineering graduate with an engineering degree [12]. Yet student persistence in NACME's *Engineering Vanguard Program* has averaged more than twice that success rate for a decade, with GPAs at 3.0. NACME has thus contradicted traditional assumptions about student potential and developed tools that are effective in augmenting standardized test scores and grades in predicting achievement for disadvantaged students. What research designs would capture how *Vanguard* and similar programs [54–56] have introduced techniques to develop academic competency, especially among students from nontraditional educational experiences? In this vein, what is the value added by preparation in a two-year institution or participation in the engineering-oriented student organizations cited earlier? What characteristics of these "gateways," *a la* the BEST design principles, apply in various institutional settings?

4) Impact of federal programs: Another decade-old approach to academic intervention, built on the precepts of the MEP model, is the National Science Foundation's Louis Stokes Alliances for Minority Participation (LSAMP) program [57]. This program encourages minority students to complete baccalaureate degrees, not just in engineering but in all STEM fields. Currently, approximately 20,000 LSAMP participants receive baccalaureate degrees in STEM fields each year. Rather than support individuals or single institutions, LSAMP creates partnerships among academic institutions (minority and majority, public and private), government agencies and laboratories, industry, and professional organizations. Arguably, LSAMP is successful because it sustains student interest in STEM fields and graduate study through hands-on research experiences, drop-in centers for program participants, and mentors and role models. But the interaction of these elements needs to be better understood. Which are essential and which dispensable? How does one invest the marginal federal dollar in legally defensible institution-wide programs to maximize the production of new engineers? Further, how can research document (1) which colleges and universities enroll and graduate significant numbers of minorities and women in engineering and (2) how accountability for outcomes rests at the institutional level, even though individual departments and other campus units are responsible for student success in entering the workforce or postgraduate programs?

C. Choices and Repercussions

If the nation fails to prepare citizens from all population groups to participate in the technology-driven economy, we risk losing our economic and intellectual preeminence. If, on the other hand, we—educators, employers, and policymakers—choose to meet this challenge, a new generation of those culturally competent can ultimately become leaders of the engineering profession—both in the faculty ranks and the corporate sector. Today, when the U.S. economy requires more STEM workers, the largest pool of potential workers continues to be isolated from STEM careers. This is not simply a K-12 or diversity problem.

The current and imminent national need thus cries out for strategies designed to create an engineering workforce that looks like America. The repercussions of not developing this wealth of minority talent extend well beyond engineering or any other profession. Companies run the risk of alienating consumers of their products, politicians risk disenfranchising groups not supported by their policies and positions, universities—especially public institutions—risk what has been called the "graceful decline model" [59].

There's more at stake here than engineering, or what ABET calls "professional skills" [60]. Stakeholders in all sectors, like it or not, "own" the problems of diversity and cultural competence. They must join together to shape the future U.S. workforce, engineering included. To do so will require a deployment of cultural resources—public policy, media, political will—to clarify the profession's image and drawing power through visible change in what it values, who participates, how it is practiced, and who benefits. The alternative is unthinkable.

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